

Report for 2003NJ47B: Potential Nitrogen Saturation in Urban Wetlands

There are no reported publications resulting from this project.

Report Follows

Project Information

Problem and Research Objectives:

It is a widely held belief that wetland systems do not experience nitrogen (N) saturation owing to their ability to remove nitrate (NO_3^-) through denitrification. However, due to hydrological alteration resulting from urban land use, urban wetlands in northeastern New Jersey may experience lowered water tables and thus overall drier conditions and wet-dry cycles that may reduce NO_3^- removal capacity. This may cause New Jersey's urban wetlands to be acting as sources rather than sinks of NO_3^- , leading to elevated NO_3^- concentrations in receiving water bodies and associated impacts on the integrity of aquatic ecosystems in this state. This research investigates the occurrence of N saturation symptoms in urban wetlands located in northeastern New Jersey and therefore directly addresses research priorities one, the integrity of aquatic and water-associated systems, and five, the impacts of land-use practice and change on water resources, of NJWRRRI's grants program. This research can also serve to direct restoration and management guidelines in the state. If it is demonstrated that lowered water tables, dry soils, and wet-dry cycles are responsible for degradation of wetland function, streambank and riparian buffer restoration projects can focus on restoring saturated hydrological conditions to these systems.

Elevated NO_3^- levels in New Jersey's streams and groundwater suggest that riparian buffers and riverine wetlands could be a management tool for improving the integrity of this state's aquatic systems. However, the existing body of research on these systems in other parts of the country and the world does not serve as an adequate predictor of riverine wetland NO_3^- removal capacity in New Jersey for several reasons. First, many of these wetlands are located in urbanized watersheds. In particular I consider the wetlands of the northeastern portion of the state in the area bounded to the west and south by I-287. This area includes the most highly urbanized region of the state. This landscape setting may critically alter structure and function of urban wetlands as compared to wetlands located in less disturbed areas. Impervious surfaces associated with urban and suburban land use result in altered hydrology in the wetlands and their receiving streams. Reduced infiltration of stormwater due to impervious cover leads to reduced groundwater recharge and flow and thus reduced baseflow. It also leads to reduced surface water storage and thus increased surface runoff following rain events. This runoff is channeled from impervious surfaces directly to receiving water bodies. The high volume of stormwater reaching receiving streams over a short period of time results in increased erosive force, which causes stream incision and downcutting. These large-scale hydrological alterations can cause or associate with hydrological alterations in wetland soils which in turn affect wetland function, in particular NO_3^- removal capacity. Stream incision and downcutting caused by high peak flows can result in lowered water tables. This means that the biologically active zone of the soil where the roots and microbial populations are located no longer experiences frequent saturation. Because denitrification requires saturated, anoxic soils, this process may be inhibited in urban wetlands as a result of lowered water tables.

I hypothesize that these hydrological alterations lead to a new hydrological regime in wetland soils which affects the ability of wetlands to retain N. Soils that were

previously saturated much of the year now experience periods of dryness followed by saturation after rain events. This new hydrological regime may have consequences for biogeochemical processes in these wetland soils and may in fact cause these systems to produce endogenous NO_3^- . The dry periods may stimulate nitrification, the microbially mediated transformation of NH_4^+ to the mobile anion NO_3^- . Following the first flush of rainfall, this mobile NO_3^- may be transported to the groundwater and then to receiving water bodies. Remaining NO_3^- should be removed by denitrification stimulated by the newly saturated soils; however, it is unclear how much of the NO_3^- produced during the dry periods will be exported before denitrification sets in. The effects of wet-dry cycles on denitrification rates have been studied in wetland systems which have been restored following drainage for agriculture and also in less disturbed wetlands which were artificially flooded in an attempt to increase nutrient removal. These studies indicated that denitrification was stimulated in dry soils following rewetting. These studies did not evaluate NO_3^- loss during the initial flush. These dynamics have not yet been investigated thoroughly in urban wetlands.

In this study I aim to:

1. Document net N mineralization, nitrification, and denitrification under wet and dry conditions in urban wetlands of contrasting soil types over the course of a one year field-based study.
2. Determine whether urban wetlands with organic and mineral soils are displaying symptoms of N saturation. For the purposes of this study, symptoms of N saturation are considered to be high rates of nitrogen mineralization and nitrification coupled with low rates of denitrification.

Methodology:

I looked for the presence or absence of N saturation in six urban wetlands adjacent to streams in northeastern New Jersey. I conducted this study in six wetlands representing the two main wetland soil types in this part of the state. The six sites consist of three depressional wetlands with organic soils and three riverine wetlands with mineral soils. The wetlands have hydrographs which display typical urban disturbance: overall low water tables and dramatic fluctuations associated with storm events. Sites are located in Paramus, Cedar Grove, Hillside, Scotch Plains, Edison, and Franklin Lakes.

Ideally the presence or absence of N saturation should be determined through measuring inputs and outputs of nitrogen in the system to generate a nitrogen budget. It is not possible to generate a full nitrogen budget, especially for six sites, with this level of funding. Instead I measured specific indicators of N saturation. These include *in situ* rates of net N mineralization, nitrification, and denitrification. High rates of nitrogen mineralization and nitrification coupled with low rates of denitrification would signal N saturation.

I used the intact static core technique developed by Tiedje and others to measure *in situ* rates of net N mineralization and nitrification. The acetylene block technique was used to measure denitrification rates on the same cores. Three replicate sets of soil cores

were taken in two locations at each site. One location was covered with a plastic tarp to keep out rain; the other location was sited out in the open. Each set of cores consisted of two cores taken from the top 15 cm of the soil. One of the two cores was returned immediately to the laboratory for analysis; the other core was returned to its hole to incubate for three to four weeks.

Upon arrival at the lab, the denitrification analysis was carried out. Rubber septa were placed on each end of the cores, and then five mls of acetylene gas were added to the headspace of each core to block denitrification from progressing from N_2O to N_2 . N_2O samples were taken after 2 hours and 6 hours (to generate a rate of denitrification) and analyzed using a Shimadzu GC-14A gas chromatograph equipped with an electron capture detector. Headspace volume was measured using a pressure transducer. After the six hour measurement samples were kept at 4°C until extracted with 2M KCl. KCl extracts are frozen until analyzed on an RFA/2 autoanalyzer for NH_4^+ and NO_3^- concentrations. The rate of net N mineralization is calculated as the amount of NH_4^+ and NO_3^- accumulated over the course of the month-long incubation; net nitrification rate is the amount of NO_3^- accumulated over the month.

Principal Findings and Significance:

Soil cores have been collected and extracted over the period of about one year. I am still in the process of analyzing both gas samples and soil extracts. As a result I do not have data to present in this report. Data will be forthcoming by the end of the summer.